AD-A266 623

(12)

ARW-201-043-TR

DTIC
S ELECTE D
JUL 7 1993
C

IRAMMP FINAL REPORT

PHILIP J. DAVIS

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

24 MAY 1993

Contract Number: N00014-89-C-0160
CDRL Number: A002

This document consists of 11 pages.

Approved:

93-13013

93 6 09 094

Areté Associates
P.O. BOX 6024, SHERMAN OAKS, CALIFORNIA 91413

SECTION 1. INTRODUCTION

This report summarizes the work that Areté has performed in support of IRAMMP under Contract Number N00014-89-C-0160. A listing of all pertinent reports and briefings associated with this program is given in Section 6. The IRAMMP project was initiated to provide critical technology support for IR surveillance needed for the passive detection of targets at extended ranges and for defense against anti-ship missiles. The overall objective of IRAMMP is to develop the ability to predict IR sensor performance for a variety of sensor, background and target parameters. The thrust of the IRAMMP project is to develop tools for IR clutter characterization to be used for both current and future IRST sensors. Areté has supported the IRAMMP goals in the general areas of: (1) field test planning and support, (2) characterization of the ocean, clouds and atmospheric effects, and (3) detection assessment. Each of these areas are discussed in the following sections.

DTIC QUALITY INSPECTED 5

St-A per telecon, Mr. Hall, ONR/Code 4412.
Arl., VA 22217.

7-7-93 JK

Accesion For	
NTIS CRA&I	☑
DTIC TAB	☐
Unannounced	☐
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and / or Special
A-1	

SECTION 2. FIELD TEST PLANNING AND SUPPORT

Areté Associates has supported the IRAMMP Field Test Program in the planning, preparation and execution of field tests [2, 7, 9, 11, 14, 23, 24, 25, 27]. Areté's requirements for field test data were driven by the modeling and analysis tasks performed for IRAMMP. Test matrices were developed to identify the key environmental and system parameters, types and quantities of data required to support the objectives of the analysis and modeling tasks. Areté provided test recommendations based on the requirements identified in the test matrix. The test matrix was periodically reviewed to reflect the field test results and emerging technical issues.

Areté conducted necessary liaison with the designated test director for each IRAMMP field test to ensure the requirements for field test data necessary to support the analysts' and modeling requirements were appropriately incorporated into the test plans. The test requirements included requirements for collecting the IRAMMP sensor data in terms of sensor settings and operating characteristics, test geometries relative to significant environmental parameters, quantities and duration of scene segments, and requirements for collecting supporting ground truth data.

Areté provided personnel to participate in the conduct of each IRAMMP field test as required to support the Government approved field test plan. Areté assisted in the collection of environmental data and special purpose data required to support specific field test requirements. The assistance included the procurement of special instrumentation and associated equipment (e.g., wave rider buoys), design and development of special purpose instrumentation and data collection systems, and the deployment and operation of field test instrumentation.

Following the Diamond Shoals tower test, Areté prepared a Hot Wash-Up briefing and report [27, 29] which summarized the objectives of the test and the degree to which the objectives were achieved. The report also summarized the data collected, known problems with the data, lessons learned, and recommendations for future tests.

SECTION 3. MODELING AND DATA ANALYSIS

Areté developed models and performed data analysis to validate these models to characterize ocean clutter, cloud clutter, and atmospheric effects. This work is summarized in the following subsections.

3.1 OCEAN CLUTTER

For ocean clutter characterization we have performed both modeling and data analysis [13, 18, 19, 29, 30, 32, 38]. IR clutter from the ocean surface contains thermal emissions from the ocean at the surface temperature, and specular reflection of the solar and atmospheric sky radiance. Clutter fluctuations are primarily induced by fluctuations in the slope of the ocean surface, causing adjacent facets of the surface to view different regions of the sky. At low grazing angles, the radiance at the camera is also modulated by the hiding of facets behind waves closer to the camera. Hiding depends upon the surface wave height and slope. Areté has developed a detailed 2-D simulator of the IR radiance received from the ocean surface which includes all of these important effects.

3.2 CLOUD CLUTTER

Clouds are an important source of IR clutter for both an airborne and ship-based IRST. In support of the IRAMMP program, Areté performed analysis of this clutter source in terms of a few key atmospheric parameters [1, 10, 21, 26, 29, 34]. The approach to this effort emphasized those features which are most relevant to IRST performance. Initially, an analytic approach to predicting sensor measured power spectral densities was developed based upon linearization of the radiative transport equation through a cloud volume. In order to better account for the highly non-linear effects and to provide a capability of generating realistic scenes for the purpose of verifying performance predictions, Areté developed a numerical 3-D cloud clutter simulator.

One of the important features of the cloud clutter distinguishing it from other clutter types is that a cloud can be partially transparent. Cumulus and stratus layers, while optically thick in most cases, can have gaps in the layers. Even through the cloudy portions of the layer are optically thick, IR radiance does penetrate sufficiently in both the long- and shortwave regions that the clutter variance is sensitive to the three-dimensional structure at scales shorter that the penetration depth (typically on the order of 50 - 100 meters). Cumulus and stratus layers would therefore be poorly simulated at these scales by modeling a cloud surface with blackbody emissions at the local surface temperature.

Cirrus cloud fields are often very thin optically, and so also do not behave as opaque blackbodies to the observer. In addition, the emissive and scattering properties of cirrus exhibit enormous variability from one cloud system to another, and also within a single cloud. Airborne measurements of cirrus ice water content have shown fluctuations an order of magnitude larger than the mean content along a path of only a few hundred meters. A simulator must be able to handle variability of this magnitude over these relatively short spatial scales.

Finally, a cloud scene simulator should incorporate the effects of the three-dimensional viewing geometry, including parallax distortion, hiding and partial hiding, and apparent relative motion of multiple cloud fields at various ranges from the sensor if the platform is moving.

Areté Associates has developed for IRAMMP a 3-D cloud scene simulator satisfying these criteria. The simulator builds three-dimensional realizations of clouds containing fluctuating temperature and optical properties, and images the clouds using radiative transfer principles. Sufficient care has been taken to build the simulator for use in both air- and ship-borne IRST scenarios.

3.3 ATMOSPHERIC EFFECTS

Atmospheric conditions affect the target and clutter contrast. Atmospheric effects on target detection include ray bending, blurring, image centroid motion and power fluctuations (scintillation). These effects have been modeled. We use LOWTRAN (and MODTRAN) to model atmospheric transmission and path radiance and standard models for atmospheric turbulence and ray bending effects [15, 29, 35].

SECTION 4. DETECTION ASSESSMENT

Areté has developed a performance model for the IRST scenarios of interest [10, 22, 29, 31, 33, 35, 37]. The approach was to integrate the clutter models developed and validated for IRAMMP into a model for predicting the expected signal-to-noise ratio (ESNR) and ROC curves, etc., for IRST scenarios of interest. The performance model is for current and advanced sensor systems, both ship-based and airborne. The modeled performance includes options for space-time signal processing, and in addition, novel signal processing such as dual color and polarization.

SECTION 5. SUMMARY

This report summarizes the work that Areté has performed in support of IRAMMP in the areas of (1) field test planning and support, (2) characterization of the ocean, clouds and atmospheric effects, and (3) detection assessment. Several tests were supported in both the planning and data collection phases. Data from the tests were analyzed to characterize ocean and cloud clutter and atmospheric effects. Data analysis results were used to validate clutter and atmospheric models developed by Areté. For detection assessment Areté has developed an IRST performance model for both current and future IRST systems. The IRAMMP clutter models were integrated into this IRST performance model.

SECTION 6. REFERENCES

1. M. Farber, "Temporal Character Background Measurements," ARW-201-002, February 6, 1990.
2. C. Forsyth, "IRAMMP Plan FY90/91," Document Number U-015-90, March 16, 1990.
3. C. Forsyth, "IRAMMP Static Analysis Update," Document Number U-042-90, March 16, 1990.
4. C. Forsyth, "IRAMMP Interim Tech Report," Document Number U-033-90, July 6, 1990.
5. L. Bliss, "Program Review," Document Number U-074-90, September 7, 1990.
6. C. Forsyth, "IRAMMP Interim Summary Briefing," ARE-201-051, December 21, 1990.
7. L. Brickman, "Summary Wave Height Data 90 Field Test," ARE-201-052, February 8, 1991.
8. L. Bliss, "Continuing Support IRAMMP Program," ARE-201-053, March 13, 1991.
9. L. Brickman, "Wallops Island Test - 1991," ARE-201-054, July 17, 1991.
10. M. Farber, "Multiband Coherent Processing," ARW-201-010, July 25, 1991.
11. L. Brickman, "Horizon Experiment Support for Wallops 91," ARE-201-055, September 13, 1991.
12. L. Bliss, "Areté IRAMMP Progress Review," ARE-201-056, September 26, 1991.
13. P. Davis, "Ocean Clutter Modeling," ARW-201-013-B, September 26, 1991.
14. L. Bliss, "Prop Sub Mast and Ant IR Detection Program," October 16, 1991.
15. J. Derderian, "A First Look at the Effects of Turbulence on IR Imaging for a Line of Sight Near the Ocean Surface - Scintillation," ARW-201-014-B, October 24, 1991.
16. M. Farber, "Areté IRAMMP Analysis Plan," ARW-201-015, December 2, 1991.
17. S. Lubard, "Technical Briefing," ARW-92-0005, January 27, 1992
18. P. Davis, "Infrared Ocean Clutter at Low Grazing Angles: Data Analysis Results and 1-D Simulation" (Briefing) ARW-201-018-B, January 29, 1992.
19. P. Davis, "Infrared Ocean Clutter and Low Grazing Angles: Data Analysis Results and 1-D Simulation" (Report), ARW-201-019-TR, January 29, 1992.
20. M. Farber, "Proposed Areté Plan to Provide Continuing Support to IRAMMP," ARW-201-022-B, April 1, 1992.
21. J. Tessendorf, "Structure of Spatial Spectra of Simulated Cloud Scenes at Infrared Wavelengths," ARW-201-025-B, April 21, 1992.

22. J. Derderian, "Preliminary Calculations of Advanced IRST Performance for Radiant Mist," ARW-201-048-B, May 14, 1992.

23. W. Martin, "IRAMMP/ASTEX Review," ARE-201-058, May 12, 1992.

24. W. Morris, "IRAMMP/ASTEX Operation Plan," ARE-201-057, June 1, 1992.

25. L. Bliss, "IRAMMP Tower Test Hot Wash Brief," ARE-201-059-B, December 16, 1992.

26. G. Widhopf, "IRAMMP," ARW-201-029-B, August 6, 1992.

27. L. Bliss, "IRAMMP Diamond Shoals Tower Test Plan," ARE-201-060-TR, February 4, 1993.

28. P. Davis, "IRAMMP Tower Test Data Analysis," ARW-201-032-B, August 27, 1992.

29. P. Davis, "Update on Areté IRAMMP Support," ARW-201-033-B, August 27, 1992.

30. P. Davis, "IR Ocean Clutter Model," ARW-201-034-B, October 20, 1992.

31. M. Farber, "IRST Performance Modeling," ARW-201-035-B, October 20, 1992.

32. P. Davis, "Areté Support of IRAMMP," ARW-201-039-B, January 15, 1993.

33. P. Davis, "A Performance Tool for IRST Systems," ARW-201-037-TR, January 22, 1993.

34. S. Church, "Simulation of Cloud Clutter for Shipboard IRST Scenarios," ARW-201-038-TR, January 12, 1993.

35. M. Farber, "A Performance Tool for IRST Systems," ARW-201-040-B, January 27, 1993.

36. P. Davis, "IRAMMP Tower Test Quick Look Results," ARW-201-041-B, February 5, 1993.

37. P. Davis, "IRST Performance Tool Status," ARW-201-042-B, February 25, 1993.